

General Secondary Education Certificate Examinations in statics

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【 الأسئلة في صفتين 】

تنبيه مهم : ١- يسلم الطالب ورقة امتحانية باللغة العربية مع الورقة المترجمة

٢- الإجابات المكررة عن أسئلة الاختيار من متعدد والصواب والخطأ لن تقدر ويتم تقدير الإجابة الأولى فقط

Remark : Calculators are allowed.

١- Gravitational acceleration $g = ٩.٨ \text{ m / sec}^٢$ الدرجة الفعلية = مجموع الدرجات $\div ٢$

٢- $(\hat{i}, \hat{j}, \hat{k})$ is the set of right hand system of unit vectors, where \hat{i}, \hat{j} are orthogonal in the direction of \vec{OX} and \vec{OY} respectively, while \hat{k} is perpendicular to their plane in direction \vec{OZ} .

I – STATICS**Answer TWO Questions ONLY from the following:**

١ - (١٠ Marks)

(a) Two forces of magnitudes F , $F + ٤$ newtons act on a particle and the magnitude of their resultant is $4\sqrt{3}$ newtons. If the line action of their resultant is perpendicular to the line action of the smaller force, find the value of F and the measure of the angle between the two forces.

(b) ABCD is a rectangle, in which $AB = ١٠ \text{ cm}$, $BC = ١٢ \text{ cm}$, and X, Y are the mid-points of \overline{AB} , \overline{CD} respectively. Forces of magnitudes ١٨, ٢٠, ١٨, ٢٠, ٢٦, ٢٦ gm.wt acted along \overrightarrow{AB} , \overrightarrow{CB} , \overrightarrow{CD} , \overrightarrow{AD} , \overrightarrow{AY} and \overrightarrow{CX} respectively.

Prove that this system is equivalent to a couple and find the norm of its moment.

٢ - (١٠ Marks)

(a) The forces $\vec{F}_1 = \hat{i} + \hat{j}$, $\vec{F}_2 = L\hat{i} + \hat{j}$, $\vec{F}_3 = \hat{i} - \hat{j}$ act at the point A (٢, ٣). If the sum of moments of these forces about the point B (-١, ١) is $٢٢\hat{k}$, find each of the constant L and the length of the perpendicular segment drawn from the point B to the line action of the resultant of these forces.

(b) \overline{AB} is a light ruler measured in centimeter rests horizontally on two supports at the points C, D such that $C \in \overline{AD}$ and $٢ AC = ٢ BD = CD$. A weight of magnitude (W) newton

suspended from the point M, lying on the ruler. The ruler is about to rotate if either a weight of ١٠ newtons is suspended at A, or a weight of ٦ newtons is suspended at B.

Find the magnitude of (W) and prove that $\frac{AM}{MB} = \frac{9}{7}$

٣ - (١٠ Marks)

(a) AB is a uniform rod of weight ٦ kg.wt (acting at its mid-point). Its end A is fixed at a hinge in a vertical wall. A horizontal force of magnitude F kg.wt acts at its end B such that the rod becomes in equilibrium in a position inclined to the vertical with an angle of measure 60° . Find the value of F and the reaction of the hinge at A.

(b) XYZL is a right angled trapezium at X in which $\overline{XL} \parallel \overline{YZ}$, $XY = XL = ١٠ \text{ cm}$ and $YZ = ٢٠ \text{ cm}$. Forces of magnitudes ٢٠, F_1 , $15\sqrt{2}$, ٥, F_2 newtons act along \overrightarrow{YX} , \overrightarrow{ZY} , \overrightarrow{LZ} , \overrightarrow{LX} and \overrightarrow{YL} respectively. If the line action of the resultant of these forces passes through the point X and is parallel to \overrightarrow{YL} , find the values of F_1 , F_2 .

الدرجة العظمى (٢٠)

الدرجة الصغرى (—)

جمهورية مصر العربية
وزارة التربية والتعليم
امتحان شهادة إتمام الدراسة الثانوية العامة
لعام ٢٠١٢ م
٤٢ شرع نموذج إجابة [الميكانيكا] بالإنجليزية

الدور الأول - المرحلة الثانية

عدد الصفحات (٩)

Total mark ٤٠/٢=٢٠

The other solutions should be considered

I : Statics

Question ١ (١٠ marks) | (a) ٥ marks + (b) ٥ marks

(A) ∴ The resultant is perpendicular to the force F

$$\therefore F + (F + 4) \cos \theta = 0 \quad \text{One mark} \quad \therefore \cos \theta = \frac{-F}{F+4} \quad \text{half} \quad (1)$$

$$\therefore R^2 = F_1^2 + F_2^2 + 2F_1F_2 \cos \theta \quad \text{One mark}$$

$$48 = F^2 + (F+4)^2 + 2 \times F \times (F+4) \times \cos \theta \quad \text{half} \quad (2)$$

from (1), (2)

$$\therefore 48 = F^2 + F^2 + 8F + 16 - 2F^2 \quad \text{half}$$

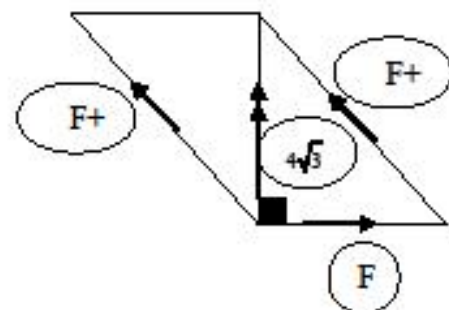
$$\therefore 8F = 32 \Rightarrow F = 4 \text{ newton} \quad \text{half} \quad \therefore \cos \theta = \frac{-4}{8} = \frac{-1}{2} \quad \text{half}$$

$$\Rightarrow m(\angle \theta) = 120^\circ \quad \text{half}$$

Another solution to find F :

$$(F + 4)^2 = F^2 + 48 \quad \text{One mark} \quad \therefore F^2 + 8F + 16 = F^2 + 48 \quad \text{One mark}$$

$$\therefore 8F = 32 \Rightarrow F = 4 \quad \text{half}$$



(B) $(xC)^2 = (12)^2 + (5)^2 = 169 \quad \therefore xC = 13 \quad \therefore Ny = \frac{12 \times 5}{13} = xH$ half

(18, 18) form couple whose moment is =

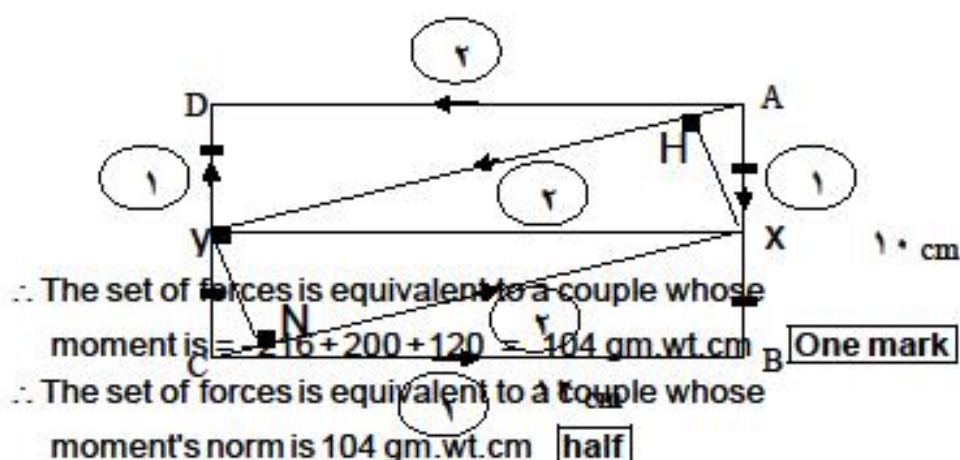
$-18 \times 12 = -216 \text{ gm.wt.cm}$ One mark

(20, 20) form couple whose moment is =

$20 \times 10 = 200 \text{ gm.wt.cm}$ One mark

(26, 26) form couple whose moment is =

$26 \times \frac{12 \times 5}{13} = 120 \text{ gm.wt.cm}$ One mark



(تراجعى الحلول الأخرى)

Question ٢ (١٠ marks) | (a) ٦ marks + (b) ٤ marks

(A)

$$\vec{R} = (2+L)\hat{i} + 12\hat{j} \quad \text{two marks}$$

$$\therefore \vec{M}_B = \vec{BA} \times \vec{R} \quad \text{One mark}$$

$$\therefore 26\hat{k} = (3\hat{i} + 2\hat{j}) \times [(2+L)\hat{i} + 12\hat{j}] \quad \text{half}$$

$$\therefore 26\hat{k} = (32 - 2L)\hat{k} \quad \text{half}$$

$$\therefore L = 3 \quad \text{half} \quad \& \quad \vec{R} = 5\hat{i} + 12\hat{j}$$

\therefore The length of the line segment drawn from the point B to the line action of

$$\text{the resultant } \vec{R} = \frac{\|\vec{M}_B\|}{\|\vec{R}\|} \quad \text{half} = \frac{26}{13} = 2 \text{ length unit} \quad \text{half}$$

(B) Let: $2AC = 2BD = CD = 2L$ cm half

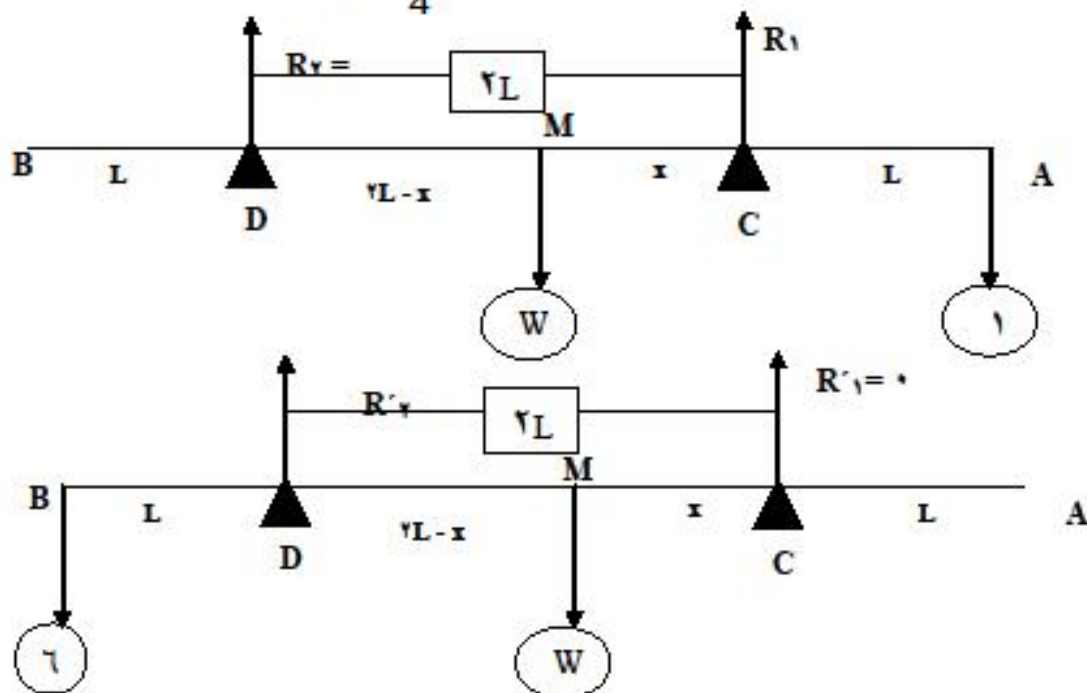
(First) $\therefore M_C = 0$ half $\therefore Wx = 10L$ (1) half

(Second) $\therefore M_D = 0$ half $\therefore 6L = W(2L - x)$
 $\therefore Wx = 2L(W - 3)$ (2) half

from (1) and (2) we get $2(W - 3) = 10 \Rightarrow W = 8$ newtons half

and from (1) $8x = 10L \Rightarrow x = \frac{5}{4}L$ half

$$\therefore \frac{AM}{MB} = \frac{L+x}{3L-x} = \frac{L+\frac{5}{4}L}{3L-\frac{5}{4}L} = \frac{9}{7} \quad \text{half}$$



(تراجعى الحلول الأخرى)

Question ٣ (١٠ marks) | (a) ٥ marks + (b) ٥ marks

(A) Assume that the line actions of the weight and the horizontal force F intersect in D

∴ The reaction "R" at the hinge must pass through the point D .

Let $AB = 4L \Rightarrow AC = 2L, BC = 2\sqrt{3}L$

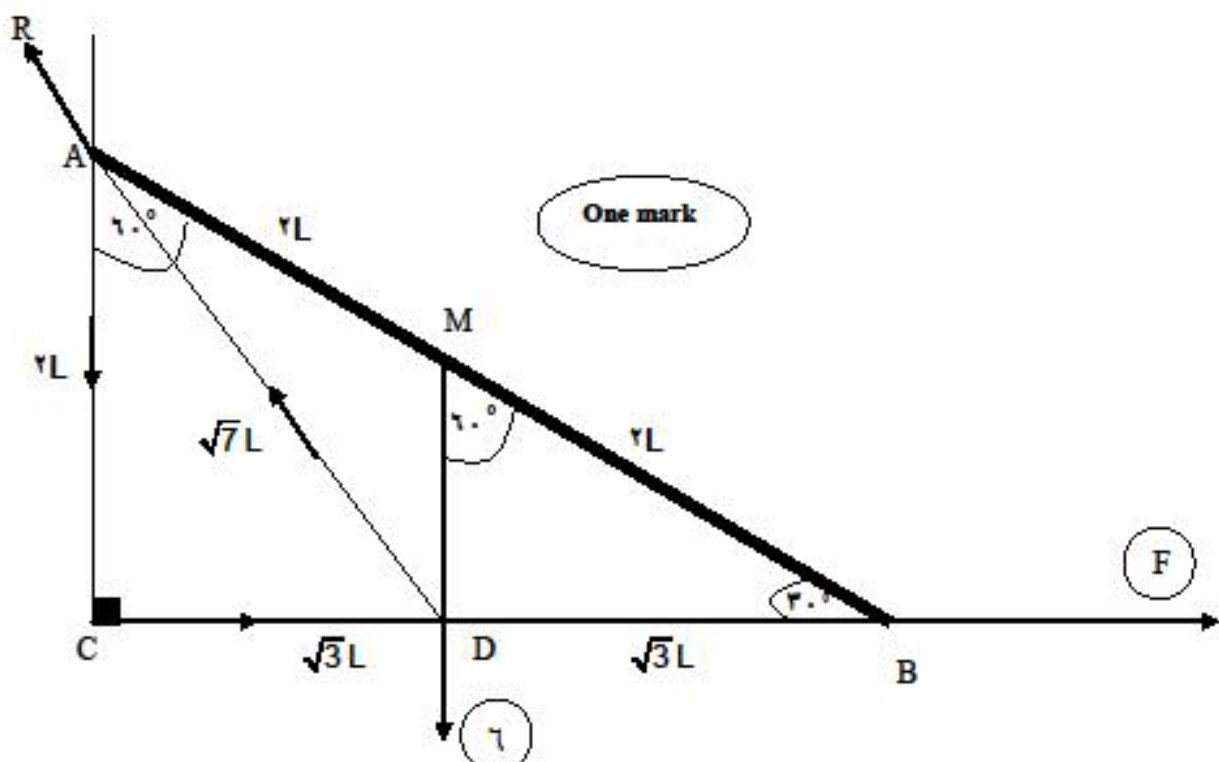
∴ $(AD)^2 = (\sqrt{3}L)^2 + (2L)^2 = 7L^2$

∴ $AD = \sqrt{7}L$ [half]

CDA is the triangle forces [half] $\Rightarrow \frac{F}{CD} = \frac{R}{DA} = \frac{6}{AC}$ [One mark]

∴ $\frac{F}{\sqrt{3}L} = \frac{R}{\sqrt{7}L} = \frac{6}{2L}$ [One mark]

∴ $F = 3\sqrt{3} \text{ kg.wt}$ [half] & $R = 3\sqrt{7} \text{ kg.wt}$ [half]



(تراجعى الحلول الأخرى)

(B) From the properties of the geometrical shape

$$LY = 10\sqrt{2} \text{ cm}, \quad XH = XN = 5\sqrt{2} \text{ cm}, \quad LM = 10 \text{ cm} \quad \text{half}$$

∴ The line action of the resultant // \vec{YL}

$$\therefore M_Y = M_L \quad \text{One mark}$$

$$\therefore -5 \times 10 + 15\sqrt{2} \times 10\sqrt{2} \quad \text{half} = F_1 \times 10 + 20 \times 10 \quad \text{half}$$

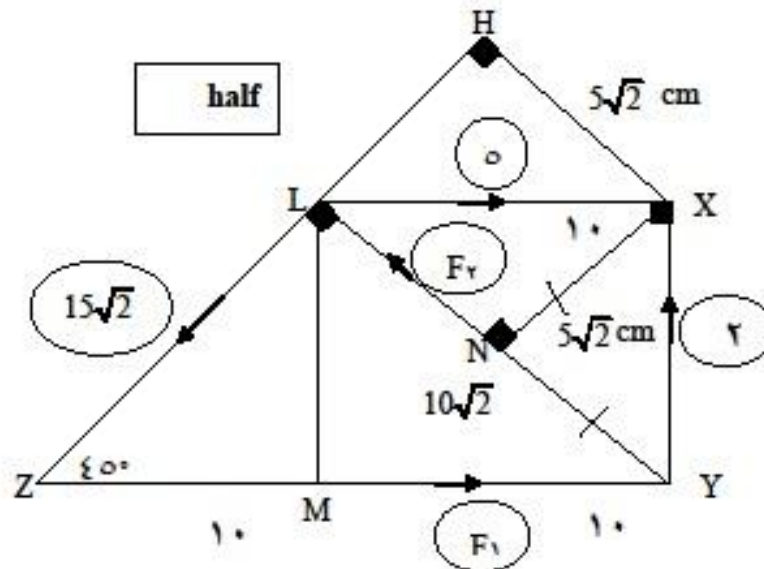
$$\therefore -5 + 30 = F_1 + 20 \quad \Rightarrow F_1 = 5 \text{ newtons} \quad \text{half}$$

∴ The line action of the resultant passes through the point X

$$\therefore M_X = 0 \quad \text{half}$$

$$\therefore -F_2 \times 5\sqrt{2} + 5 \times 10 + 15\sqrt{2} \times 5\sqrt{2} \quad \text{half} = 0$$

$$\therefore \sqrt{2} F_2 = 40 \quad \Rightarrow F_2 = 20\sqrt{2} \text{ newtons} \quad \text{half}$$



(تراجعى الحلول الأخرى)



General Secondary Education Certificate Examination, 2011
[Second Stage – First Session]

Mechanics [Mathematics (2)]

Time: 2 Hours

الميكانيكا [رياضيات (٢)] باللغة الإنجليزية

[الأسئلة في صفتين]

تنبيه هام : يسلم الطالب ورقة امتحانية باللغة العربية مع الورقة المترجمة

Remark : Calculators are allowed.

(1) Gravitational acceleration $g = 9.8 \text{ m / sec}^2$

(2) $(\hat{i}, \hat{j}, \hat{k})$ is the set of right – hand system of unit vectors, where \hat{i}, \hat{j} are orthogonal in the direction of \vec{ox} and \vec{oy} respectively, while \hat{k} is perpendicular to their plane .

I - STATICS

Answer TWO Questions ONLY from the following

- 1 - (a) Two forces of magnitudes 4 , F kg.wt acts on a particle and the measure of the angle between them is 120° . If the line action of their resultant is perpendicular to the line action of the first force. Find the value of F , then find the magnitude of the resultant of the two forces .
- (b) The force $\vec{F} = L\hat{i} + M\hat{j}$, acts at the point $A = (2, -1)$ and the algebraic measure of its moment about the point $B = (1, 4)$ equals 11 moment unit , and its moment about the point $D = (-1, 3)$ vanishes. Find the magnitude of \vec{F} .
- 2 - (a) AB is a rod of length 100 cm and of weight 20 Newton acts at its midpoint, rests in a horizontal position on two supports, one of them is at a distance 30 cm from A , and the other is at a distance 20 cm from B. Find the magnitude of the pressure on each of the two supports. Find the magnitude of the weight that should be suspended at B such that the rod is about to rotate. Then Find the value of the pressure on the support which is nearest to the point B at this instant.
- (b) ABCD is a rectangle , in which $AB = 9 \text{ cm}$, $BC = 24 \text{ cm}$. H , F are the mid points of \overline{BC} , \overline{AD} respectively . Forces of magnitudes 18 , 48 , 30 , 24 gm.wt act along \vec{AB} , \vec{BC} , \vec{CF} and \vec{FA} respectively. Prove that this system is equivalent to a couple , and find its moment norm. Then find the magnitude of the two forces which act along \vec{HA} , \vec{FC} such that the two forces will be in equilibrium with the given forces.
- 3 - (a) A smooth sphere of weight 30 Newton rests on a smooth vertical wall and is suspended from a point on its surface by a light string, the other end of the string is attached to a point on the wall vertically above the point of contact between the wall and the sphere . If the length of the string equals the radius of the sphere . Find the tension in the string and the reaction of the wall in state of equilibrium.
- (b) ABC is an isosceles triangle in which $m(\angle A) = 120^\circ$, forces of magnitudes 4 , 4 and $4\sqrt{3}$ kg.wt are acting along \vec{AB} , \vec{AC} and \vec{BC} respectively . Prove that the line action of the resultant of these forces passes through the midpoint of \overline{BC} and parallel to \vec{AC}

[بقية الأسئلة في الصفحة التالية]

الدرجة الكلية : (٤٠) درجة تم تقسم على (٢) لتصبح الدرجة الفعلية (٢٠) درجة

أولاً : الاستاتيكا

إجابة السؤال الأول (عشر درجات) الفقرة (a) خمس درجات ، الفقرة (b) خمس درجات

(a)

∴ The resultant \perp to the first force ∴ $\vec{F}_1 + \vec{F}_2 \cos \alpha = 0$

$$4 + F \left(\frac{-1}{2} \right) = 0$$

$$F = 8 \text{ kg.wt}$$

$$R' = F_1' + F_2' + 2 F_1 F_2 \cos \alpha$$

$$\therefore R' = 16 + 16 - 2 \times 4 \times 8 \times \frac{1}{2} = 48$$

$$\therefore R = 4\sqrt{3} \text{ kg.wt}$$

(b)

$$\vec{M}_B = \vec{BA} \times \vec{F}$$

$$11\hat{k} = (\hat{i} - 5\hat{j}) \times (L\hat{i} + M\hat{j})$$

$$11\hat{k} = (M + 5L)\hat{k}$$

$$\therefore M + 5L = 11 \quad \dots\dots\dots (1)$$

$$\vec{M}_D = \vec{DA} \times \vec{F}$$

$$0 = (3\hat{i} - 4\hat{j}) \times (L\hat{i} + M\hat{j})$$

$$0 = (3M + 4L)\hat{k}$$

$$\therefore 3M + 4L = 0 \quad \dots\dots\dots (2)$$

$$\text{From (1), (2)} \quad L = 3, \quad M = -4 \quad \therefore \vec{F} = (3\hat{i} - 4\hat{j})$$

$$\|F\| = \sqrt{9+16} = 5 \text{ force unit}$$

إجابة السؤال الثاني (عشر درجات) الفقرة (a) خمس درجات ، الفقرة (b) خمس درجات

(a) The first case :

$$R_D + R_C = 20 \dots\dots\dots (1)$$

$$M_D = 0 \quad \therefore R_C \times 20 - 20 \times 20 = 0$$

$$\therefore R_C = 20 \text{ Newton}$$

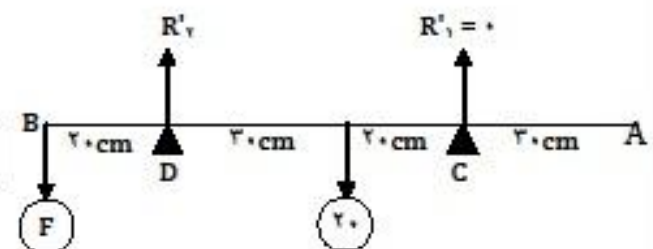
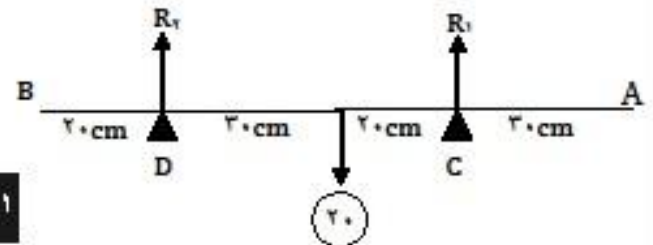
$$\text{From (1): } R_D = 0 \text{ Newton}$$

The second case :

$$M_D = 0 \quad \therefore F \times 20 - 20 \times 20 = 0$$

$$F = 20 \text{ Newton}$$

$$R'_D = 20 + 20 = 40 \text{ Newton}$$



$$(b) \quad \frac{18}{9} = \frac{48}{24} = \frac{30}{15} = \frac{24}{12} = 2$$

\therefore Forces are proportional with sides length and act in same cyclic order

\therefore The system equivalent to a couple its moment :

$$M = -2 \times 2 \times \frac{12+24}{2} \times 9 = -144 \text{ Newton} \cdot \text{cm}$$

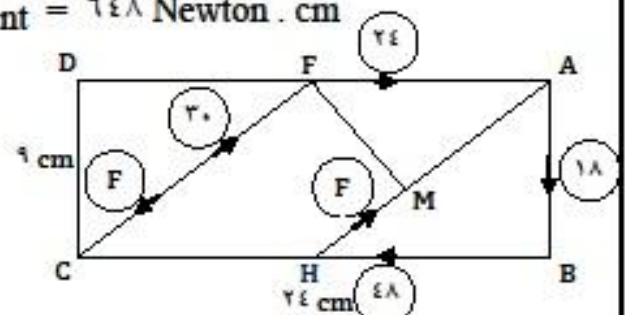
The system equivalent to a couple its moment = -144 Newton . cm

(F, F) are two forces form a couple its moment = 144 Newton . cm

$$F \times 12 \sin \angle DAM = 144$$

$$F \times 12 \times \frac{9}{15} = 144$$

$$\therefore F = 20 \text{ Newton}$$



تراجعى الحلول الأخرى

إجابة السؤال الثالث (عشر درجات) | الفقرة (a) خمس درجات ، الفقرة (b) خمس درجات

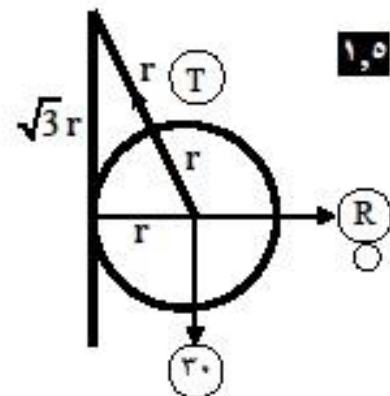
(a)

By using the triangle force rule :

$$\therefore \frac{T}{2r} = \frac{R}{r} = \frac{30}{\sqrt{3}r}$$

$$\therefore T = 20\sqrt{3} \text{ Newton}$$

$$\therefore F = 10\sqrt{3} \text{ Newton}$$



(b)

Let $AB = AC = L$ cm

$\therefore BC = \sqrt{3} L$ cm , D mid of \overline{BC}

$$M_D = -4 \times \frac{\sqrt{3}}{2} L \sin 30^\circ + 4 \times \frac{\sqrt{3}}{2} L \sin 30^\circ$$

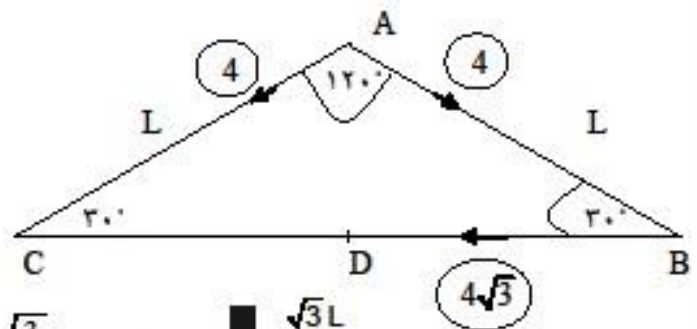
$$= 0$$

Line action of resultant passing through mid of \overline{BC}

$$M_A = -4 \sqrt{3} L \sin 30^\circ = -2 \sqrt{3} L \text{ kg.wt. cm}$$

$$M_C = -4 L \sin 30^\circ = -2 \sqrt{3} L \text{ kg.wt. cm}$$

(٣) \longleftrightarrow





[الأسئلة في صفحتين]

تنبيه مهم : ١- يسلم الطالب ورقة امتحانية باللغة العربية مع الورقة المترجمة

٢- الإجابات المكررة عن أسئلة الاختيار من متعدد والصواب والخطأ لن تقدر ويتم تقدير الإجابة الأولى فقط

Remark : Calculators are allowed.١- Gravitational acceleration $g = ٩.٨ \text{ m / sec}^٢$ الدرجة الفعلية = مجموع الدرجات $\div ٢$ ٢- $(\hat{i}, \hat{j}, \hat{k})$ is the set of right hand system of unit vectors, where \hat{i}, \hat{j} are orthogonal in the direction of \vec{OX} and \vec{OY} respectively, while \hat{k} is perpendicular to their plane in direction \vec{OZ} .**I – STATICS****Answer TWO Questions ONLY from the following:**

١ - (١٠ Marks)

(a) Two forces of magnitudes $F, F\sqrt{2}$ Newton act on a particle and include between them an angle of measure 135° . Find the measure of the inclination angle of the resultant to the greater force, then find the value of F when the magnitude of their resultant equals $3\sqrt{2}$ Newton.

(b) ABCD is a square of side length ١٠ cm . x, y are the mid points of $\overline{AD}, \overline{DC}$ respectively. Forces of magnitudes $F, K, ١٨ \text{ gm. wt}$ act along $\vec{AB}, \vec{CB}, \vec{CD}$ respectively. If the line action of their resultant is \vec{xy} , find the values of F, K .

٢ - (١٠ Marks)

(a) A body of weight ٢٤ gm. wt is placed on a smooth plane inclined to the horizontal at an angle θ° where $\tan \theta = \frac{3}{4}$. The body is kept in equilibrium under the action of a horizontal force of magnitude $F \text{ gm. wt}$. Find the value of F and the reaction of the plane to the body.

(b) \overline{AB} is a non-uniform rod of length (one meter) and weight ٢٥ kg. wt . It rests in a horizontal position on two supports at C, D where $AC = BD = ١٠ \text{ cm}$. If a weight of magnitude ٥٠ kg. wt is hanged at its end A , then the rod is about to rotate around C . Find the point of action of the rod weight, then find the maximum weight that can be suspended at B , without disturbing the equilibrium and without removing the weight at A .

٣ - (١٠ Marks)

(a) The force $\vec{F} = L\hat{i} + M\hat{j}$ acts at the origin point O . If the algebraic measure of its moments about the two points $A = (٢, ٠), B = (٠, ٢)$ equal $٩, ١٢$ moment unit, respectively, find the value of L, M and then find the length of the perpendicular segment drawn from the point B to the line action of this force.

(b) ABCD is a rectangle in which $AB = ٤ \text{ cm}, BC = ٧ \text{ cm}$. The point $E \in \overline{BC}$ such that $CE = ٢ \text{ cm}$. Forces of magnitudes $٦, ١٤, ٦, ١٠$ and $٨\sqrt{2} \text{ gm. wt}$ acted along $\vec{AB}, \vec{AD}, \vec{CD}, \vec{DE}$ and \vec{EA} respectively. Prove that the system is equivalent to a couple and find the norm of its moment.

**Remark :** Calculators are allowed.(1) Gravitational acceleration $g = 9.8 \text{ m / sec}^2$ (2) $(\hat{i}, \hat{j}, \hat{k})$ is the set of right – hand system of unit vectors, where \hat{i}, \hat{j} are orthogonal in the direction of \vec{ox} and \vec{oy} respectively, while \hat{k} is perpendicular to their plane .**I - STATICS****Answer ONLY TWO Questions from the following**

- 1 - (a) Two forces of magnitudes $4, 2\sqrt{3} \text{ kg.wt}$ acts on a particle and the measure of the angle between them is 150° find the magnitude of their resultant and the measure of the angle which makes with the greatest forces .
- (b) The force $\vec{F} = 6\hat{i} - 8\hat{j}$, acts at the point $A = (1, 2)$. Find the moment vector of this force about the point $B = (-3, -1)$, then find the length of the perpendicular segment drawn from the point B to the line action of the force.
- 2 - (a) AB is a uniform rod of length 120 cm and of weight 15 Newton acts at its midpoint, rests in a horizontal position on two supports, one of them is at the end A and the other at a point 20 cm distance from B, find the magnitude of the weight that should be suspended at B such that the magnitude of the reaction on the nearest support to this end equals three time the magnitude of the reaction on the support A , hence find the magnitudes of these reactions at this instant .
- (b) ABCD is a square of side length 20 cm , Forces of magnitudes 6 , 7 , 6 , 7 Newtons acting along $\vec{AB}, \vec{CB}, \vec{CD}$ and \vec{AD} respectively , and two forces each of magnitude $4\sqrt{2}$ Newtons acting at the points A , C in the direction of \vec{BD}, \vec{DB} respectively . Find:
- 1) Norm of the moment of the couple that equivalent to this system of forces.
 - 2) The magnitude and direction of two forces acting at B, D which are both parallel to \vec{AC} and make the system in equilibrium .
- 3 - (a) A weight of magnitude 200 gm wt is suspended by two strings of lengths 60 cm , 80 cm from two points on the same horizontal line, the distance between them 100 cm . Find the tension in each string.
- (b) ABCD is a rectangle in which $AB = 8 \text{ cm}$, $BC = 6 \text{ cm}$, H is the mid-point of \vec{AB} , forces of magnitudes 2 , 3 , 4 , 5 , $5\sqrt{13}$ Newton acting along $\vec{BC}, \vec{DC}, \vec{DA}, \vec{BD}$ and \vec{HC} respectively . Find the algebraic sum of the moments of these forces about each of the points B , C.

Remark : Calculators are allowed.

(1) Gravitational acceleration $g = 9.8 \text{ m / sec}^2$

(2) $(\hat{i}, \hat{j}, \hat{k})$ is the set of right – hand system of unit vectors, where \hat{i}, \hat{j} are orthogonal in the direction of \vec{ox} and \vec{oy} respectively, while \hat{k} is perpendicular to their plane .

I – STATICS

Answer TWO Questions ONLY from the following

1 - (a) Two forces of magnitudes $6\sqrt{3}$, 6 Newton act on a particle and the measure of the angle between them is 150° . Find the magnitude of their resultant and the measure of the angle which it makes with the greater force.

(b) The two forces $\vec{F}_1 = 5\hat{i} - \hat{j}$, $\vec{F}_2 = \hat{i} + 9\hat{j}$ act at the point $A = (1, 3)$

Find the moment vector of their resultant with respect to the point $B = (5, 0)$, then calculate the length of the perpendicular drawn from the point B to the line of action of the resultant.

2- (a) ABCD is a parallelogram , in which $AB = 18 \text{ cm}$, $BC = 20 \text{ cm}$, $m(\hat{A}) = 30^\circ$
Forces of magnitudes 8 , 6 , 8 , 6 Newtons act along \vec{BA} , \vec{BC} , \vec{DC} and \vec{DA} respectively.
Prove that this system is equivalent to a couple then find the norm of its moment, then find the magnitude of each of the two forces which act at A , D and are perpendicular to \vec{AD} and equivalent to the previous system .

(b) A uniform wooden beam AB (its weight acts at its midpoint) of length 16 m , and its a weight is 40 kg.wt . , rests in a horizontal position on two supports, one of them is at distance of 2 meter from A , and the other is at a distance of 4 meter from B. If a man whose weight is 80 kg.wt ascended on the beam , find the magnitude of the reaction of each of the two supports on the beam when the man stands at A . If the man move on the beam starting from A towards B, find the maximum distance which the man can moves such that the beam does not overturn.

3- (a) A body of weight 12 Newtons is suspended from one end of a light string whose length 130 cm . The other end is fixed at a point in the vertical wall, the body is pulled by a horizontal force which makes it at equilibrium when it is at distance 50 cm from the wall. Find the magnitude of each of the force and the tension in the string .

(b) Two forces \vec{F}_1, \vec{F}_2 act at the two points A , B respectively in perpendicular direction on \vec{AB} where $AB = 30 \text{ cm}$, and their resultant $\vec{R} = -3\hat{i} + 4\hat{j}$ act at the point $C \in \vec{AB}$ given that $\vec{F}_2 = -6\hat{i} + 8\hat{j}$ determine \vec{F}_1 and the length of \vec{BC}

Remark : Calculators are allowed.

(1) Gravitational acceleration $g = 9.8 \text{ m / sec}^2$

(2) $(\hat{i}, \hat{j}, \hat{k})$ is the set of right – hand system of unit vectors, where \hat{i}, \hat{j} are orthogonal in the direction of \vec{ox} and \vec{oy} respectively, while \hat{k} is perpendicular to their plane .

I – STATICS

Answer TWO Questions ONLY from the following

- 1 - (a) The coplanar forces of magnitudes 2, 4, $2\sqrt{3}$ Newton act on a particle along the directions east, 60° north of the east, 30° south of the west respectively . Find the magnitude of the resultant of these forces and the measure of the angle between the resultant and the first force .
- (b) A B is a uniform rod of length 180 cm and weight of magnitude 120 Newton (acting at its middle) . The rod is suspended horizontally by two vertical light strings at its ends . Find the position of suspending (on the rod) a weight of magnitude 300 Newton so that the magnitude of the tension at the end A is double the magnitude of the tension at the end B .
- 2- (a) The force $\vec{F} = 3\hat{i} - 3\hat{j}$ act at the point $A = (0, 3)$, Find The moment vector of \vec{F} with respect to the two points $B = (4, 3)$, $E = (-2, 1)$. Hence prove that the line of action of \vec{F} bisects \overline{BE} .
- (b) ABC is a right angled triangle at B, in which $AB = 3 \text{ cm}$, $BC = 4 \text{ cm}$. Forces of magnitudes 12, 16, 20 Newton act along \overline{AB} , \overline{BC} , \overline{CA} respectively . Prove that the system of these forces is equivalent to a couple then find the norm of its moment . Also find the magnitudes of the two forces which act at A, C and are perpendicular to \overline{AC} which make the system to be in equilibrium .
- 3- (a) A body whose weight is of magnitude 9 Newton is placed on a smooth plane which inclines to the horizontal at angle of measure 30° . The body is kept in equilibrium by a force of magnitude F Newton which inclines to the line of the greatest slope of the plane at angle of measure 30° upwards . Find the value of F , then find the magnitude of the reaction of the plane on the body.
- (b) ABCD is a trapezium in which $m(\angle ABC) = m(\angle BDC) = 90^\circ$, $\overline{AD} \parallel \overline{BC}$, $AB = 12 \text{ cm}$, $BC = 25 \text{ cm}$ and $AD = 9 \text{ cm}$. Forces of magnitudes 75, F, 50 Newton act along \overline{DA} , \overline{BA} , \overline{DB} respectively . If the algebraic sum of the measure of moments of these forces about C vanishes, find F . Then find the algebraic sum of the measure of moments of these forces about E where $E \in \overline{BC}$, $BE = 5 \text{ cm}$